Effect of Temperature and Pressure on the Performance of a PEMFC during CO Poisoning

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Introduction

In the use of Polymer Electrolyte Membrane (PEM) fuel cells for automotive applications, hydrogen can be produced on board by reforming methanol or other hydrocarbon fuels. The reformer typically produces hydrogen rich gas containing up to 1% carbon monoxide. Although Pt has proven to be the most effective catalyst for hydrogen oxidation, this catalyst creates problems when the fuel gas contains CO. Even a few parts per million levels of CO cause substantial poisoning of the anode electrocatalyst in the fuel cell.

Recently, the decay and recovery of fuel cell performance in response to step changes in the level of CO in the anode fuel stream has been studied[1, 2]. Here we expand that data to include the effects of the cell temperature and reactant back-pressure on these transient responses. The data obtained in this study may be useful for commercial PEM fuel cell systems operating with high CO levels. Data are reported for cell temperatures of 70°C and 90°C, low reactant stoichiometries and back-pressure up to 15 psig. Poisoning and recovery rates are reported for saturated conditions utilizing CARBEL™ CL gas diffusion media. Also, the data show the effects of air-bleed treatment on the fuel cell performance.

Experimental

The experiments focus on the performance of PEM fuel cells in the presence of high concentrations of CO (up to 3000 ppm CO) in the anode stream. These consisted of two parts. For the first part, steady state polarization curves were obtained at 70°C and 90°C in the presence of neat hydrogen and mixtures of CO in H_2. The gases used in the experiment were 500 and 3000 ppm CO in H_2. After recording a polarization curve with neat H_2, polarization curves in CO/H_2 mixtures with and without air-bleed were obtained. We used 5 % air for 500 ppm CO and 15 % air for 3000 ppm CO. In the second part of the experiment, transient tests with CO/H_2 mixture gas were conducted to study the decay and recovery of the MEA. For the transient experiments, the current density was fixed at 0.6 A/cm^2. The effects of two different baselines (neat H_2 and 50 ppm CO in H_2) were studied in these experiments.

All of the data reported here were obtained with PRIMEA® Series 5561 Membrane Electrode Assemblies (MEAs), comprising GORE-SELECT® membranes (thickness of 25 μm) and catalyst loadings of 0.45 mg/cm^2 Pt alloy on the anode and 0.4 mg/cm^2 Pt on the cathode. The electrode active area was 20 cm^2 and a triple channel serpentine flow field was used on both the anode and cathode sides. The gas diffusion medium (GDM) used in these experiments was CARBEL™ CL (thickness of 0.41 mm). Compressible gaskets of appropriate thickness were employed so that the internal pressure on the gas diffusion media was approximately at 150 psi (clamp torque 50 in-lb_f /bolt).

Fuel cell test stations manufactured by Fuel Cell Technology, Inc. (Albuquerque, NM) were used in all experiments. The gases used in this study were high purity hydrogen with specified concentrations of CO and bottled air. The stoichiometries were 1.2 for hydrogen and 2.0 for air.

Results and Discussion

Figures 1 and 2 show representative experimental data from this study. Figure 1 shows the temperature effects on the performance of PEM fuel cell in the presence of 500 and 3000 ppm CO. The performance is comparable at 70 and 90°C cell temperature with neat hydrogen. As expected, when CO was introduced in the anode stream, the cell performance at 70°C is decreased more significantly than at 90°C. Figure 2 shows poisoning and recovery rates under transient operation with 3000 ppm CO with alternate cycles of CO contamination and neat hydrogen.

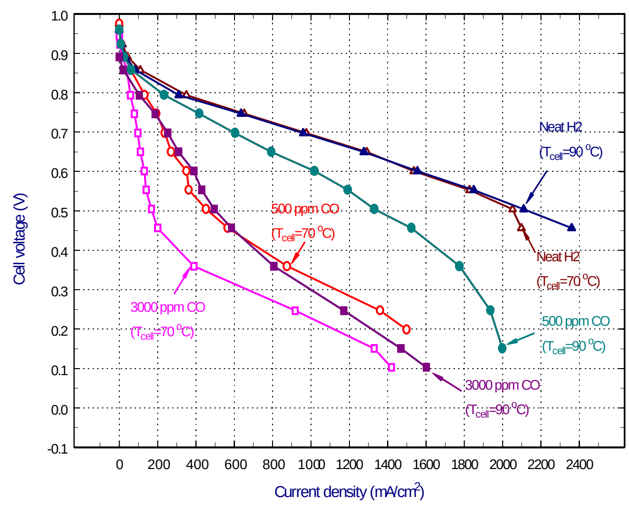

Figure 1. Performance comparison between 70°C and 90°C cell temperature in the presence of 500 and 3000 ppm CO (P(A/C) = 15/15 psig).

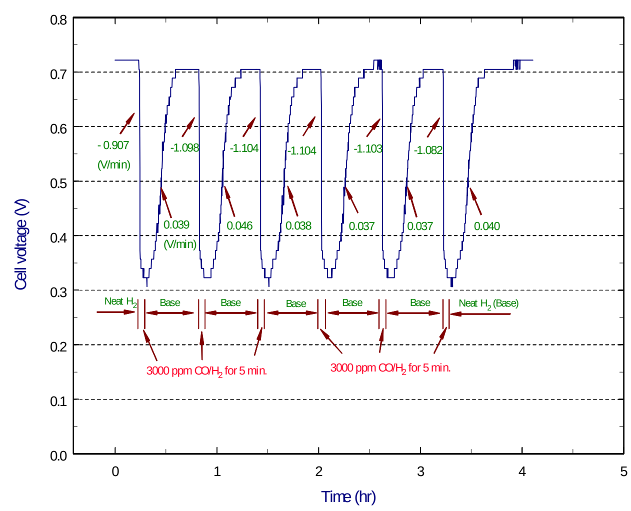

Figure 2. Transient performance with neat hydrogen and 3000 ppm CO at 600 mA/cm^2 with CARBEL™ CL GDM. (T_{cell} = 70°C and P(A/C) = 15/15 psig)

References

1. J.W. Bauman, T.A. Zawodzinski and S. Gottesfeld, *Electrochemical Society Proceedings*, **98-27,** 136 (1999).
2. M. Murthy, M. Esayian, A. Hobson, S. MacKenzie, W. Lee and J.W. Van Zee, *Electrochemical Society Meeting Abstract*, **2001-1**, 120 (2001).